

**SCIENCE, AERONAUTICS, AND TECHNOLOGY  
FISCAL YEAR 1998 ESTIMATES  
BUDGET SUMMARY**

**OFFICE OF SPACE FLIGHT  
MISSION COMMUNICATIONS SERVICES**

**SUMMARY OF RESOURCES REQUIREMENTS**

<b>MISSION COMMUNICATIONS SERVICES</b>	<b>FY 1996</b>	<b>FY 1997</b>	<b>FY 1998</b>
Ground Networks	259,500	245,600	224,700
Mission Control and Data Systems	162,800	147,100	145,000
Space Network Customer Service	27,200	25,900	31,100
<b>Total</b>	<b>449,500</b>	<b>418,600</b>	<b>400,800</b>

<b>Distribution of Program Amount by Installation</b>	<b>FY 1996</b>	<b>FY 1997</b>	<b>FY 1998</b>
Johnson Space Center	--	8,200	--
Marshall Space Flight Center	3,000	1,300	2,100
Dryden Space Flight Center	13,900	15,000	14,500
Lewis Research Center	10,100	9,800	10,000
Goddard Space Flight Center	228,515	194,800	202,800
Jet Propulsion Laboratory	190,172	185,700	169,000
Headquarters	3,813	3,800	2,400
<b>Total</b>	<b>449,500</b>	<b>418,600</b>	<b>400,800</b>

**PROGRAM GOALS**

The Space Communications goal is to enable the conduct of the NASA strategic enterprises by providing telecommunications systems and services. Reliable electronic communications are essential to the success of every NASA flight mission, from planetary spacecraft to the Space Transportation System (STS) to aeronautical flight tests.

The National Space Policy stipulates that NASA will "seek to privatize or commercialize its space communications operations no later than 2005". The Space Operations Management

Office (SOMO), located at the Johnson Space Center, manages the telecommunication, data processing, mission operation, and mission planning services needed to ensure the goals of NASA's exploration, science, and research and development programs are met in an integrated and cost-effective manner. In line with the National Space Policy, the SOMO is committed to seeking and encouraging commercialization of NASA operations services and to participate with NASA's strategic enterprises in collaborative interagency, international, and commercial initiatives. As NASA's agent for operational communications and associated information handling services, the SOMO seeks opportunities for using technology in pursuit of more cost-effective solutions, highly optimized designs of mission systems, and advancement of NASA's and the nation's best technological and commercial interests.

The Mission Communications Services are composed of Ground Networks, Mission Control and Data Systems, and Space Network Customer Service. These programs establish, operate, and maintain NASA ground networks, mission control, and data processing systems and facilities to provide communications service to a wide variety of flight programs. These include deep space, Earth-orbital, research aircraft, and sub-orbital missions. Mission support services such as orbit and attitude determination, spacecraft navigation and maneuver support, mission planning and analysis and other mission services are provided. New communications techniques, standards, and technologies for the delivery of communication services to flight operations teams and scientific users are developed and applied. Radio spectrum management and data standards coordination for NASA are conducted under this program.

## **STRATEGY FOR ACHIEVING GOALS**

The Space Communications program provides command, tracking and telemetry data services between the ground facilities and flight mission vehicles and all the interconnecting telecommunications services to link tracking and data acquisition network facilities, mission control facilities, data capture and processing facilities, industry and university research and laboratory facilities, and the investigating scientists. The program provides scheduling, network management and engineering, pre-flight test and verification, flight system maneuver planning and analysis for selected missions. The program provides integrated solutions to operational communications and information management needs common to all NASA strategic enterprises.

The range of telecommunications systems and services are provided to conduct mission operations, enable tracking, telemetry, and command of spacecraft and sub-orbital aeronautical and balloon research flights. Additionally, services and systems are provided to facilitate data capture, data processing, and data delivery for scientific analysis. The program also provides the high speed computer networking, voice and video conferencing, fax, and other electronic mail services necessary to administer NASA programs.

These communications functions are provided through the use of space and ground-based

antennas and network systems, mission control facilities, computational facilities, command management systems, data capture and telemetry processing systems, and a host of leased interconnecting systems ranging from phone lines and satellite links to optical fibers.

The program provides the necessary research and development to adapt emerging technologies to NASA communications needs. New coding and modulation techniques, antenna and transponder development, and automation applications are explored and, based on merit, demonstrated for application to future communications needs. NASA's flight programs are supported through the study and coordination of data standards and communication frequencies to be used in the future. These are all parts of the strategic approach to providing the vital communications systems and services common to all NASA programs and to achieve compatibility with future commercial satellite systems and services.

Many science and exploration goals require inter-agency or international cooperation in order to be achieved. NASA's Space Communications assets are provided through collaborative agreements to other U.S. Government agencies, commercial space enterprises, and international cooperative programs. Consistent with the National Space Policy, NASA will purchase commercially available goods and services to the fullest extent feasible, and will not conduct activities with commercial application that preclude or deter commercial space activities.

The Mission Communications Services program, one part of NASA's Space Communications program, provides services to a large number of NASA missions, including planetary and interplanetary missions; human space flight missions; near-Earth and Earth-orbiting missions; sub-orbital and aeronautical test flights.

Efforts are ongoing to consolidate and streamline major support contract services in order to optimize space operations. In FY 1996, a voluntary contractor partnership was established between the major incumbents, AlliedSignal Technical Services Corporation and Computer Sciences Corporation. Transition to a Consolidated Space Operations Contract (CSOC) is planned. The CSOC acquisition process will be implemented in two phases. In FY 1997, multiple short-term fixed-price study contracts to develop an Integrated Operations Architecture (IOA) are planned. In FY 1998, a single cost-plus-award-fee, ten-year contract is envisioned to implement the IOA. A full and open competition is planned to develop an integrated architecture and implementation across all NASA programs to produce efficiencies and economies over the life of the contract.

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## **GROUND NETWORK**

<b><u>BASIS OF FY 1998 FUNDING REQUIREMENT</u></b> <b>(Thousands of Dollars)</b>	<b>FY 1996</b>	<b>FY 1997</b>	<b>FY 1998</b>
Deep Space Network - Systems	102,000	92,900	80,900
Deep Space Network - Operations	84,600	87,500	80,600
Spaceflight Tracking and Data Network - Systems	6,100	2,400	3,000
Spaceflight Tracking and Data Network - Operations	22,200	19,300	17,100
Aeronautics, Balloons, and Sounding Rockets - Systems	19,600	19,400	20,000
Aeronautics, Balloons, and Sounding Rockets - Operations	25,000	24,100	23,100
<b>Total</b>	<b>259,500</b>	<b>245,600</b>	<b>224,700</b>

## **PROGRAM GOALS**

The Ground Networks program goal is to provide high quality, reliable, cost-effective ground-based tracking, command and data acquisition systems and services for NASA science and aeronautics programs. Launch, emergency communications, and landing support for the STS is also provided by Ground Networks facilities. The program provides for the implementation, maintenance and operation of the tracking and communications facilities necessary to fulfill program goals for the NASA flight projects.

The Ground Network program also supports NASA programs in collaborative interagency, international, and commercial enterprises and independently provides support to other national, international and commercial enterprises on a reimbursable basis.

## **STRATEGY FOR ACHIEVING GOALS**

The Ground Networks program is comprised of the following elements: the Deep Space Network (DSN), managed by the Jet Propulsion Laboratory (JPL); the Spaceflight Tracking and Data Network (STDN), managed by the Goddard Space Flight Center (GSFC); the Aeronautics, Balloon and Sounding Rocket (AB&SR) tracking and data acquisition facilities managed by GSFC/Wallops Flight Facility (WFF); and the Western Aeronautical Test Range (WATR), managed by the Dryden Flight Research Center (DFRC).

The AlliedSignal Technical Services Corporation and the Computer Sciences Corporation are the primary support service contractors responsible for ongoing engineering and operations of the Ground Networks. For GSFC, the two contractors established a voluntary partnership in 1996 for engineering and operations support under the Consolidated Network and Mission Operations (CNMOS) performance-based contract.

The number of missions serviced by the DSN facilities and the needs of the individual missions will increase dramatically over the next several years. In anticipation of the increases, new antenna systems have been developed and obsolete systems are being phased out or converted for alternate uses. The DSN is being reconfigured with three new 34-meter antenna systems located at Goldstone, California; Canberra, Australia; and Madrid, Spain. These 34-meter antennas will enable the expanded coverage requirements and provide simultaneous coverage of two deep space missions which are in critical phases. In Goldstone, two new 34-meter antennas became operational in FY 1995 and FY 1996. In Canberra, one will become operational in FY 1997. In Madrid, one will become operational in FY 1998. In addition, two experimental 34-meter antennas were obtained by NASA at Goldstone from the Army. The first of these former Army antennas became operational in early FY 1996 and is currently supporting the European Space Agency (ESA)-NASA collaborative Infrared Space Observatory and Solar Observatory for Heliospheric Observations spacecraft. Activities on the second Army antenna have been deferred due to constrained budget authority.

The DSN installed a new 11-meter antenna system at each DSN complex to provide data acquisition capability for the Institute of Space and Astronautical Science (ISAS) Japanese VLBI Space Operation Program (VSOP) spacecraft, which is scheduled for launch in February 1997.

Other new Ground Networks capabilities include 11-meter antenna systems at the University of Alaska, Fairbanks, and at the WFF Orbital Tracking Station for use with the Japanese/U.S. Advanced Earth Orbiting Satellite mission (ADEOS) and other NASA missions. Two additional 11-meter antenna systems are under contract by WFF to provide data acquisition capability for the expanded number of Earth-observing missions. One of these 11-meter antennas will be installed at Svalbard, Norway, and the other antenna will be installed near Fairbanks, Alaska.

When required, the Ground Networks program develops new capabilities to support unique requirements of NASA and NASA Cooperative Science missions, such as the Galileo S-band Mission Telemetry Array which utilizes a full-spectrum-recording technique and arrays the signals received simultaneously at antennas in Australia and California. The reference frequency transfer for VSOP and the world-wide coverage provided for ADEOS are other examples of enabling capabilities.

The strategy for achieving the above goals has five major elements:

- The DSN is the premier facility for tracking deep space probes. It is occasionally supplemented by the facilities of other agencies or nations. For example, the Australian Parkes radio telescope antenna is used to complement DSN coverage for the Galileo mission.

- The communications needs of present and future Earth resource observation missions can be partially or completely serviced by commercially available systems. NASA will obtain these systems from U.S. industry on a competitive basis.
- NASA is actively working with industry to foster the enhancement of existing "commercial-off-the-shelf" systems to expand their applicability, so that inexpensive and reliable telecommunications services can be readily obtained for the new small-class missions. Future missions will be supported by small, inexpensive, commercially available tracking systems.
- The Ground Networks program, in conjunction with other NASA elements, is demonstrating and implementing Global Positioning System (GPS) flight units on NASA sponsored missions. This demonstration will seek to minimize future tracking and navigation activities, resulting in lower operational costs. Two planned flights, Lewis and Student Nitric Oxide Explorer (SNOE), will demonstrate these new capabilities using commercial flight units as the primary source of this function.
- The WATR is striving for even more efficiency as it provides NASA's capability for tracking, data acquisition, and mission control for a wide variety of flight research vehicles. The WATR provides both on-orbit and landing support to the STS and communications with the Mir Space Station. Intense planning is underway to support the X-33 RLV Technology Flight Demonstrator with WATR resources.

The following cost reduction initiatives are underway:

- The cost of operating the DSN is being reduced through re-engineering efforts now in process. These new processes will allow the DSN to double the tracking hours delivered while reducing the cost of these processes substantially. The processes to be implemented include: moving toward giving the operators end-to-end control of the entire data acquisition process; redesigning systems that provide support data to allow automation and quicken response time; and developing a process to better define DSN services and allow customers to choose only the services necessary to support the mission.
- Efforts to reduce the cost of operations for low-Earth orbit spacecraft will continue with development of new technology and operational processes. The goal of these efforts is to provide turn-key mini-systems that can be operated directly by the flight projects. This concept will be validated by the Lewis Project and SNOE Project.
- Re-engineering efforts will continue on the STDN facilities to reduce operation and maintenance costs. NASA will close the Bermuda station, following completion of two planned STS modifications. One will permit earlier communications through the

Tracking and Data Relay Satellite (TDRS) during the launch phase of the mission and the second will allow onboard use of the GPS to replace the use of ground radar for STS navigation. Closure of the Bermuda station is anticipated in FY 1999.

- NASA will pursue, within the CSOC, commercial ground tracking services for low-Earth orbit missions that require this support. Transition activities to the commercial operator are expected to begin in FY 1999. Upon successful completion of transition activities, the 26-meter subnet will be operated at a reduced level until FY 2001 in order to meet prior commitments. The DSN will return to servicing only deep space missions, highly elliptical Earth orbiting missions, ground-based radio astronomy, and planetary radar astronomy activities.

## **MEASURES OF PERFORMANCE**

	<b><u>FY 1996</u></b> <b><u>Plan</u></b>	<b><u>FY 1996</u></b> <b><u>Actual</u></b>	<b><u>FY 1997</u></b> <b><u>Plan</u></b>	<b><u>FY 1997</u></b> <b><u>Revised</u></b>	<b><u>FY 1998</u></b> <b><u>Plan</u></b>
<b>Deep Space Network</b>					
Number of NASA missions	46	46	45	45	45
Number of hours of service	73,000	73,000	93,000	90,000	92,000
<b>Spaceflight Tracking and Data Network</b>					
Number of STS launches	7	8	7	7	7
Number of ELV launches	10	26	6	18	6
<b>Wallops Flight Facility</b>					
Number of NASA Earth-Orbiting missions	30	30	30	33	33
Number of Sounding Rocket deployments	28	22	30	25	25
Number of Balloon deployments	22	25	22	26	26
Number of hours of service (Wallops Orbital Tracking)	31,000	26,720	31,000	23,000	26,000
<b>Western Aeronautical Test Range</b>					
Number of NASA missions	1790	967	2236	1,100	1,100
Number of NASA research flights	620	304	780	400	400

The FY 1997 and FY 1998 increase in DSN hours of service beyond the plan/actuals for FY 1996 was due to mission coverage for missions whose launches were delayed from previous years, such as Total Ozone Mapping Spectrometer (TOMS), Fast Auroral Snapshot Explorer (FAST), and International Solar Terrestrial Physics (ISTP)/Polar. In addition, the delay in decommissioning DSS-12 provided several months of available support which had not been anticipated. The increase in ELV support in FY 1996 and FY 1997 includes commercial and DOD launches. The changes to the Balloon and Sounding Rockets mission model plans were driven by customer readiness to launch. The reduced WFF orbital tracking in FY 1996 and FY 1997 is due to reduced mission requirements, particularly the International Ultraviolet Explorer (IUE) mission. The decrease in WATR support is attributed to early success in research programs which made some flights unnecessary and delays in completing aircraft modifications.

## **ACCOMPLISHMENTS AND PLANS**

In FY 1996, the STS launches were successfully supported through dedicated facilities of the STDN. The two major requirements for the STDN are always, without exception, to be available during the launch countdown sequence so as not to cause a launch hold condition, and to provide at least 99% of the STS data during the launch phase. These requirements were met 100% of the time. The continuation of this support, further enabled by the implementation of the re-engineered STDN system elements, is expected throughout FY 1997 and FY 1998.

The Galileo spacecraft reached Jupiter and began its tour of the Galilean moons. Antennas at the DSN stations in Australia and the Parkes Radio Telescope will be arrayed with the 70-meter antenna in California to enable a greater return of Galileo science data over the next two years. In the area of educational outreach, NASA is working with the Apple Valley Science and Technology Center in California to encourage young people to become interested in Radio Astronomy and space communications. An obsolete 34-meter antenna at Goldstone, California is being reconfigured as a radio telescope to become an instrument for education.

WFF completed the installation of an 11-Meter Telemetry Antenna System at the University of Alaska's Synthetic Aperture Radar Facility. The system will primarily support the Japanese/U.S. Advanced Earth Observing Satellite Mission (ADEOS). WFF completed installation and testing of a Redstone Telemetry system at the White Sands Missile Range (WSMR). WFF also completed installation of a Redstone Telemetry System at Poker Flat Research Range. Both of these units will support sounding rocket launches. A 10-Meter Telemetry antenna, at the McMurdo Ground Station, became operational to support the Earth Resources Satellite (ERS) and RADARSAT missions. A contract was awarded to procure one Low Earth Orbit-Tracking (LEO-T) system with option to procure additional systems in the future.



The WATR supported over 1,000 aeronautics missions as well as all STS missions and Mir operations on a daily basis. Over 350 research flights were supported, many with extended duration (3 to 8 hours). In addition, combined system tests, full mission simulations, and data playbacks were conducted. Range safety and space positioning support for long duration, environmental research platforms and communications and tracking support for hosted programs (such as DarkStar) were provided. New challenges have been to post-flight process very high bandwidth data recorded onboard the Supersonic Laminar Flow Control research aircraft, and to develop an extended range capability for X-33 testing.

In FY 1997, the DSN will support two launches of the Mars Exploration Program. The Pathfinder Mission will land in July 1997, and Mars Global Surveyor (MGS) will begin orbital operations in September 1997. The Galileo Mission continues with the critical part of the tour, using the DSN array mode. Operational support for the ADEOS mission will continue. The VSOP spacecraft will launch in February 1997 and will begin a very complex operational scenario involving the 11-meter antennas for VSOP telemetry and the DSN 70-meter antennas for co-observing of the radio sources.

Low and sub-orbital flight mission services will be provided by permanent and transportable tracking facilities. These facilities will service low-Earth orbit, sounding rocket, and atmospheric balloon missions. WFF will install 11-meter systems in Svalbard, Norway and Fairbanks, Alaska, that will provide backup and housekeeping support to the Earth Observation System (EOS) AM-1 spacecraft and the Landsat-7 spacecraft. WFF will upgrade the MGS to provide command uplink and expanded S-Band downlink capabilities. FAST will be the first NASA mission to use these capabilities. The first LEO-T system will be installed and tested in Fairbanks, Alaska where it will initially support SNOE. A second LEO-T will be placed under contract for future installation at WFF. WFF will provide downrange ground station support, including telemetry, command, and radar, for the X-33 project at DFRC.

The Western Aeronautical Test Range will refurbish the DFRC radar systems; continue replacement of graphic displays in the mission control center; and overhaul DFRC telemetry antennas. The presentation of research data in real-time to researchers remote from DFRC is a key element to future success of the WATR and the research missions it supports. The "Virtual Flight Research Center" and "Virtual Control Room" concepts will evolve based on work already done within the mission control community and the application of new network technology.

In FY 1998, both Cassini, bound for Saturn, and Lunar Prospector, a Discovery mission, will launch and be supported by the DSN. MGS will complete its orbital aerobraking and begin mapping the planet Mars. In July of 1998, the first of the Deep Space New Millennium missions will launch. About a month later, the Japanese Space Agency, ISAS, will launch Planet B, a Mars mission which will be supported by the DSN on a cooperative basis.

The capability to receive data from several spacecraft in a single beam will be implemented. This is required because of the number of missions that will be orbiting on the surface of Mars. This implementation will allow the DSN to better use the limited number of antennas that are available.

The aging DSN 34-meter standard antennas at Australia and Spain will be decommissioned. The support formerly provided by these antennas will be assumed by the newly constructed 34-meter antennas.

Re-engineering of the DSN network control system is ongoing and is scheduled for completion in FY 1999. Automated equipment will enable a single "connection operator" at a Complex to control the acquisition of data from a spacecraft and deliver it to a project.

The second LEO-T will be installed and tested at WFF. The modernization of the WFF FPQ-6 radar will be completed and verified. The automation of the Wallops Optical Tracking Station will be completed, tested and validated.

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### **MISSION CONTROL AND DATA SYSTEMS**

<b><u>BASIS OF FY 1998 FUNDING REQUIREMENT</u></b> <b><u>(Thousands of Dollars)</u></b>	<b><u>FY 1996</u></b>	<b><u>FY 1997</u></b>	<b><u>FY 1998</u></b>
Mission Control - Systems	10,800	10,500	13,400
Mission Control - Operations	43,200	43,700	46,500
Data Processing - Systems	46,800	40,400	39,700
Data Processing - Operations	62,000	52,500	45,400
<b>Total</b>	<b>162,800</b>	<b>147,100</b>	<b>145,000</b>

### **PROGRAM GOALS**

The Mission Control and Data Systems program goal is to provide high-quality, reliable, cost-effective mission control and data processing systems and services for GSFC spaceflight missions; data processing for NASA's Spacelab program; and flight dynamics requirements for NASA flight projects. The program provides for data systems, telecommunications systems technology demonstrations, and coordination of data standards and communications frequency allocations for NASA flight systems. The Mission Control and Data Systems program provides for the implementation, maintenance, and operation of the mission control and data processing facilities necessary to ensure the health and safety and the sustained level of high quality performance of NASA flight systems. In addition, the program advocates

sustaining U.S. economic and technological leadership in commercial space communications and fostering the development of the National Information Infrastructure and the Global Information Infrastructure.

## **STRATEGY FOR ACHIEVING GOALS**

The Mission Control and Data Systems program, primarily managed by the GSFC, is comprised of a diverse set of facilities, systems and services necessary to support NASA flight projects. The AlliedSignal Technical Services and Computer Sciences Corporation are the support service contractors responsible for ongoing engineering support, development, operations and maintenance, under the Consolidated Network and Mission Operations (CNMOS) performance based contract, established as a voluntary partnership in 1996.

The mission control function consists of planning scientific observations and preparing command sequences for transmission to spacecraft to control all spacecraft activities. Mission Operation Centers interface with flight dynamics and communications network facilities in preparation of command sequences, perform the real-time uplink of command sequences to the spacecraft systems, and monitor the spacecraft and instrument telemetry for health, safety, and system performance. Real-time management of information from spacecraft systems is crucial for rapid determination of the condition of the spacecraft and scientific instruments and to prepare commands in response to emergencies.

Mission control facilities operated and sustained under this program are Mission Operation Centers (MOC) for the Hubble Space Telescope (HST) program; the ISTP/Wind, ISTP/Polar, and Solar Observatory for Heliospheric Observation (SOHO); X-ray Timing Explorer (XTE), TOMS-Earth Probe (EP), Solar, Anomalous, and Magnetospheric Particle Explorer (SAMPEX) and FAST missions, and the Multi-satellite Operations Control Center (MSOCC) which supports the Compton Gamma Ray Observatory (CGRO), Upper Atmospheric Research Satellite (UARS), Extreme Ultraviolet Explorer (EUVE), Earth Radiation Budget Satellite (ERBS), and International Monitoring Platform (IMP) missions. Data processing support is provided for ISTP/Geomagnetic Tail (Geotail).

The EUVE and the CGRO system are phasing into a new Transportable Payload Operations Control Center (TPOCC) architecture of distributed workstations, first used for the SAMPEX mission. NASA's SAMPEX, FAST, and Submillimeter Wave Astronomy Satellite (SWAS) missions will be operated from a common control facility for Small Explorer missions. The SWAS Mission Operations Center has been completed. Tropical Rainfall Measuring Mission (TRMM), Advanced Composition Explorer (ACE), Transport and Atmospheric Chemistry near Equator (TRACE), and Wide Field Infrared Explorer (WIRE) control centers are in development. These workstation systems will allow for increased mission control capability at reduced cost.

The first launch of a Medium-class Explorer (MIDEX) is currently scheduled for November 1999. Approximately one spacecraft per year will be launched, with potentially every other MIDEX mission operated from GSFC, dependent on successful Principal Investigator teaming arrangements. To minimize operations costs, plans for the MIDEX missions include consolidating the spacecraft operations, flight dynamics and data processing all into a single multi-mission control center. The control center system will be used for spacecraft integration and test, thereby eliminating the need and cost of spacecraft manufacturers integration and test systems.

GSFC is presently working with the University of California Berkeley (UCB) to install and test the TPOCC architecture in the EUVE Mission Operations Center. EUVE operations will be outsourced to UCB in mid-1997. Other mission control systems include the STS Payload Operations Control Center (POCC) Interface Facility (SPIF) and the Command Management System. The STS POCC Interface Facility was successfully transitioned to the TPOCC architecture in FY 1996. The SPIF provides a single interface to Mission Control Center for use of spacecraft mission control facilities to access spacecraft deployed by the STS. The Command Management System generates command sequences to be used by mission control centers. A User Planning System, currently being upgraded to a workstation based environment, is provided for scheduling communications with spacecraft supported by the Tracking and Data Relay Satellite System (TDRSS); the Flight-to-Ground Interface Engineering Center provides flight software pre-flight and in-flight simulation and development support for GSFC flight systems; and, an Operations Support Center maintains status records of in-flight NASA systems.

The data processing function captures spacecraft data received on the ground, verifies the quantity and quality of the data and prepares data sets ready for scientific analysis. The data processing facilities perform the first order of processing of spacecraft data prior to its distribution to science operations centers and to individual instrument managers and research teams.

Data processing facilities include the Packet Data Processing (PACOR) facility, the Data Distribution Facility, and the Telemetry Processing Facility. The PACOR facility utilizes the international Consultative Committee for Space Data Systems data protocol to facilitate a standardized method of supporting multiple spacecraft. PACOR provides a cost-effective means of processing flight data from the following spacecraft missions: SAMPEX, EUVE, CGRO, SOHO, SWAS, XTE, TRMM, and HST.

The Data Distribution Facility performs electronic and physical media distribution of NASA space flight data to the science community. The Data Distribution Facility has been a pioneer in the use of Compact Disk-Read Only Memory technology for the distribution of spacecraft data to a large number of NASA customers.

Specialized data processing services are provided by the Telemetry Processing Facility for the ISTP missions (Wind, Polar, and Geotail), and the Spacelab Data Processing Facility, located at the MSFC, processes data from STS payloads. Specialized telemetry processing systems for NASA's Space Network are also provided under this program.

The Mission Control and Data Systems program provides for the operation, sustainment, and improvement of NASA's Flight Dynamics Facility (FDF). Funding for the FDF is used to: provide orbit and attitude determination for operating NASA space flight systems, including the TDRS and the STS; develop high-level operations concepts for future space flight systems; modify existing FDF systems to accommodate future missions; develop mission-unique attitude software and simulator systems for specific flight systems; generate star catalogues for general use; and conduct special studies of future orbit and attitude flight and ground system applications. It is critical to continuously know the location of spacecraft so as to communicate with the system and to know the orientation of the spacecraft to assess spacecraft health and safety and to perform accurate scientific observations. The type and level of support required by spacecraft systems is dependent on the design of its on-board attitude and control systems, including its maneuver capabilities, and the level of position and pointing accuracy required of the spacecraft. Automated orbit determination systems for TDRS and other spacecraft systems are also under development.

Besides the operation of currently deployed spacecraft and the modification and development of mission control and data processing systems to accommodate new flight systems, the program also supports the study of future flight missions and ground system approaches. Mission control and first-order data processing systems are less costly systems. Yet, proper economy of mission planning requires solutions that integrate ground and flight system development considerations. Special emphasis is given by the Mission Control and Data Systems program to seeking integrated solutions to spacecraft and ground systems designs that emphasize spacecraft autonomy; ease and low cost of operation; reuse of software; and selected use of advanced technology to increase the return of space flight system investments at equal or lower cost than is required to support today's mission systems.

The Mission Control and Data Systems program supports advanced technology development at GSFC and JPL. The GSFC team, including contractors and universities, provides advanced technology in several areas, such as tracking and data acquisition future systems; communications and telemetry transport; and advanced space systems for users. The JPL team advances technology in multiple areas such as spacecraft radio systems development and optical communications development; communications systems analysis; and flight demonstrations. The Mission Communication Services advanced technology development has two forms: near term (1-3 years) demonstration and application of data management and telecommunications technology and procedures; and long-range (3-5 years) development of ground and space flight communications systems. Consideration of innovative applications of commercial "off-the-shelf" technology is emphasized. Such applications often open new

market opportunities to suppliers of these technologies resulting from their NASA experience.

A critical element of the Mission Control and Data Systems program is the securing of adequate frequency spectrum resources which are required in the performance of all flight missions, piloted and unpiloted, including spectrum for all active emitters as well as passive sensors. NASA continues to coordinate frequency spectrum requirements with other federal agencies, industry and regulatory bodies to obtain all requisite authorization to operate telecommunications systems associated with NASA programs. Consistent with its charter pursuant to both the Space Act of 1958 and the Communications Satellite Act of 1962, NASA is the primary advocate, both domestically and internationally, for obtaining the unique frequency spectrum allocations required by the commercial sector to exploit satellite technology for future generation telecommunications systems. In compliance with the 1992 Telecommunications Authorization Act, NASA actively participates in the Interdepartment Radio Advisory Committee to establish National and International management policies.

### **MEASURES OF PERFORMANCE**

	<b><u>FY 1996 Plan</u></b>	<b><u>FY 1996 Actual</u></b>	<b><u>FY 1997 Plan</u></b>	<b><u>FY 1997 Revised</u></b>	<b><u>FY 1998 Plan</u></b>
Number of NASA spacecraft supported by GSFC mission control facilities	16	16	17	14	17
Number of mission control hours of service	50,000	49,000	52,000	50,000	55,000
Number of billions of bits of data processed	13,500	15,500	12,000	27,000	38,000
Number of NASA missions provided flight dynamics services	34	35	33	32	38

The current FY 1997 column reflects IUE termination, and ICE solar occultation. The FY 1998 plan reflects the SWAS, ACE, and TRMM launches. Increased bits of data processed reflects science instrument change out on the HST. FY 1998 plan reflects a planned launch for TRACE and transfer of EUVE to the University of California at Berkeley. The number of missions provided flight dynamics services reflects the current mission model and includes pre-Phase A and Phase A support for missions such as Earth Orbiter (EO)-1, Venus 2000, and Next Generation Space Telescope.

## **ACCOMPLISHMENTS AND PLANS**

In FY 1996, the Mission Control and Data Processing program has pursued proactive measures to consolidate functions, close marginal facilities, and reduce overall contractor workforce to reflect the Agency's goals. Examples include the transition of CGRO and EUVE MOC operations to TPOCC workstation systems as a step to MSOCC closure and the installation of HST science processing to PACOR with attendant closure of the more costly HST Data Capture Facility.

Mission control was performed for the HST, CGRO, UARS, EUVE, IUE, SAMPEX, FAST, ICE, IMP-8, ERBS, TOMS-Meteor, TOMS-EP, XTE, ISTP/WIND, ISTP/POLAR, and ISTP/SOHO. In FY 1996, the XTE, ISTP/POLAR, ISTP/SOHO, TOMS-EP, and FAST spacecraft were deployed under the control of GSFC mission control facilities.

Packet data processing operations were provided for the HST, CGRO, EUVE, SAMPEX, FAST, SOHO, TOMS-EP, and XTE. The Time Division Multiplexed services were provided for the Geomagnetic Tail, UARS, ERBS, ICE, IMP-8, National Oceanic and Atmospheric Administration (NOAA)-10, POLAR, and WIND. Data processing for the Spacelab missions was performed at MSFC.

Orbit determination of the TDRS itself was provided, and flight dynamics services were provided to all NASA space flight missions that utilize NASA's Space Network and to selected elements of the Ground Network, including the STS, Expendable Launch Vehicles, and satellite systems. A new operations concept for flight dynamics was developed. The new concept defines an approach to reduce flight dynamics costs by implementing new technology.

Among systems implementation projects in FY 1996, development of TPOCC systems for the upcoming TRMM and ACE spacecraft continued, including the procurement of workstations, processors, and software. TOMS-EP has been integrated into the TOMS mission control center. Modifications of the Command Management System effecting workstation deployment to specific MOC's progressed, with CGRO the only residual mission operating on a reduced configuration IBM mainframe. TPOCC development for the CGRO and EUVE missions continued in order to allow closure of the aging MSOCC facility by FY 1998. Preparations for the Second Servicing Mission for the HST continue with ground system software changes being made to accommodate the planned new space systems. FY 1996 marked the initiation of innovative spacecraft integration and test and mission operation single system ground support development efforts for both the MIDEA Microwave Anisotropic Probe (MAP) and Small-class Explorer (SMEX) TRACE and WIRE MOC's.

The spacecraft managed by GSFC's mission control facilities are supported by various NASA communications networks, including the TDRSS, the DSN, the WFF, and transportable ground systems. A wide range of communications and systems interfaces must be managed

to accomplish the function of mission control. NASA mission operations personnel support the planning and development of future mission systems and continuous changes to operational spacecraft software systems, as well as the operation of current ground control systems.

Transfer of data systems technologies to flight project use occurred in the areas of software reuse, Very Large Scale Integration (VLSI) applications, expert system monitoring of spacecraft control functions, and packet data processing systems. Software reuse, expert systems, VLSI user interface, workstation environments, and object-oriented language applications continued. The Mission Control and Data Systems programs will continue to integrate modern technology into mission operations support systems through the use of systems like the Generic Spacecraft Analyst Assistant for automation, software-based telemetry front-end processing systems and the Mission Operations Planning and Scheduling System, and is exploring the use of case based reasoning tools.

In support of Advanced Technology Development, planning and implementation continued on demonstrating optical laser communications between the ground and an Earth-orbiting spacecraft using the JPL ground facilities and the Japanese ETS-VI satellite. A contract was placed for a 4th-generation, lightweight, low-power-consuming radio transponder for users of the TDRSS.

NASA continues to exercise its responsibilities for space communications in a cooperative manner with our international partners. We continued strategic planning panels with ESA and the National Space Development Agency (Japan) and instituted new relationships with the French Centre National d'Etudes Spatiales and German Aerospace Research Establishment organizations. We also established the groundwork for similar panels with the Russian Space Agency.

Consistent with the National Space Policy calling for the use of private sector communications systems by the government, initial steps were taken to identify technologies as well as systems and programmatic issues relative to the use of commercial assets.

In FY 1996, a detailed sharing assessment was conducted at the request of the White House Office of Science and Technology Policy to examine the feasibility of sharing between NASA Space Science systems and Local Multipoint Distribution Service (LMDS) systems near 27.5 GHz. The analysis, which showed the potential for harmful interference to space science systems, resulted in a decision by the Federal Communications Commission not to allocate spectrum below 27.5 GHz for LMDS.

In FY 1997, conversion of CGRO and EUVE to TPOCC systems will be completed, permitting the closure of the MSOCC facility. Attitude software and simulator development is being provided for the TRACE, WIRE, ACE, and TRMM flight systems. Transitioning the



FDF to a workstation environment will be completed in FY 1997. The ACE, SWAS, and TRMM missions will be supported by GSFC's data processing program in FY 1997.

Reimbursable support will be provided to seven missions, including GOES and NOAA programs. Support will begin for ACE and TRMM missions in FY 1997. Mission planning for future missions such as TRACE, WIRE, FUSE, Landsat-7, and EOS will be performed.

Advanced technology will continue. The 4th generation TDRSS radio transponder engineering unit is underway. Work on deep space radio transponders and data coding technology continues.

FY 1997 will be a transitional year for many aspects of the Mission Control and Data Systems program. Mission Control and Data Systems will provide Mission Control Flight Dynamics and Data Processing service for the SWAS, TRMM and ACE missions scheduled to be launched in FY 1997. The SAMPEX mission will continue migrating operations to the University of Maryland at Bowie State, and transition of EUVE mission operations responsibilities to the University of California, Berkeley will be completed. Support to ICE will terminate. Significant development, test, and pre-launch support associated with MIDEX, and the SMEX missions, are part of the Mission Control and Data Systems activity.

The ACE and TRMM mission control centers (MCC) will be completed in FY 1997 and the ACE mission will be added to the data processing operational workload. Emphasis upon commercial products, artificial intelligence applications and advanced graphical displays will be accelerated in FY 1997 for application in MIDEX and future SMEX missions. NASA's Command Management System is evolving to workstation-based systems integrated within spacecraft MCC capabilities.

In FY 1997, the HST Second Servicing Mission will be conducted from the HST control center; and transition to support of the next series of SMEX missions will begin. Development efforts will take place in preparation for TRACE, WIRE, and MIDEX missions. Efforts will continue for the FY 1997 HST Servicing Mission.

In FY 1997, the Mission Operations and Data Systems program will focus efforts at re-engineering selected ISTP/Wind, Polar, SOHO, and IMP ground elements to achieve dramatic reductions in recurring operations costs, enabling continued science operations beyond current termination dates. To promote operations automation in FY 1997, Mission Control and Data Systems will intensify development efforts on the XTE and EUVE Automated POCC (APOCC) and the CGRO Reduced Operations by Optimizing Tasks and Technologies effort. Automation will be provided for TRACE to promote single shift staffing for operations. Mission Control and Data Systems will actively lead and participate in establishing Renaissance directions and rapid prototyping, exploring system autonomy concepts, and use of commercial-off-the-shelf products.

Mission Control and Data Systems program will continue the lead in scoping and prototyping Mission Operations Control Architecture (MOCA) elements such as: the use of Transmission Control Protocol/Internet Protocol or Space Communications Protocol Standards for ground and flight communications; the use of knowledge-based control languages; ground and space autonomy; and active participation in the American Institute of Aeronautics and Astronautics Spacecraft Control Working Group to infuse emerging operations standards in the areas of satellite control. Exploration of the promise of advanced communications technologies will continue throughout this period.

In FY 1998, TRACE development will be completed, the MSOCC system will be closed, and the EUVE control center support will be completely transitioned to the University of California at Berkeley. Developments will continue for the MDEX and SMEX series as well as for the Earth Orbiter (EO)-1 mission. Development efforts on WIRE, MAP, Imager for Magnetopause-to-Aurora Global Exploration (IMAGE), EO-1, and similar missions will realize benefits from modern technology, commercial products, and more cost-effective processes (for example, a single system to perform spacecraft integration and test and mission operations; skunkworks development teams; etc.).

A new Flight Dynamics Facility (FDF) operations concept to perform routine operations as integral functions within mission control centers will be fully implemented in FY 1998. Portable (capability to operate anywhere) FDF support systems will be developed to facilitate distributed operations. The systems will offer options for customer operations, integrated operations and central operations. New technology development for autonomous space and/or ground spacecraft navigation and control will be major efforts.

In FY 1997, the space communications NASA/Industry/Academia alliance will be established. An industry workshop will be conducted by May 1997 to define technologies for NASA mission use. Studies will be initiated and databases created to explore the ability of emerging commercial assets to satisfy a portion of the Agency's communications needs. In FY 1997 and continuing through FY 1999, the alliance will become the primary vehicle for collaboratively developing pre-competitive technologies and conducting service enabling demonstrations of mutual benefit to the industry and NASA.

NASA and DoD continue to conduct joint technology projects in three key areas: more efficient use of the radio frequency spectrum; standardization of link and upper-level communications protocols for greater interoperability; and, miniaturization of global positioning satellite receivers for small satellite utilization. Efficient modulation techniques, with better than a 10-to-1 reduction in bandwidth requirement over present modulation techniques, will continue to be analyzed with follow up implementation of the most promising theoretical concepts. The seamless interface of space links with ground network fiber-optic stems will be analyzed and demonstrated by continuing the Space Communications Protocol

Standards (SCPS) project. In addition, the evolution of link protocols to allow greater flexibility and demonstrations of upper level protocols to achieve improved interoperability and seamless communications between ground and space networks, will be initiated using the Mission Operations Control Architecture test bed. The use of onboard GPS receivers for navigation of small spacecrafts will require additional technology in miniaturization of current GPS receivers. NASA and DoD will continue to conduct joint design and evaluation projects for this purpose.

Work will continue on identifying future World Radiocommunications Conference (WRC) topics including advocating spectrum for space-to-space use of the Global Positioning Satellite network. The Spectrum program will support and advocate NASA's interest in WRC-97 and WRC-99.

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### **SPACE NETWORK CUSTOMER SERVICES**

<b><u>BASIS OF FY 1998 FUNDING REQUIREMENT</u></b> <b>(Thousands of Dollars)</b>	<b><u>FY 1996</u></b>	<b><u>FY 1997</u></b>	<b><u>FY 1998</u></b>
Space Network Customer Services	27,200	25,900	31,100

### **PROGRAM GOALS**

The Space Network Customer Service program goal is to provide high quality, reliable, cost-effective customer access to the multi-mission space telecommunications network serving all TDRS-compatible Earth orbiting and suborbital flight missions and to provide network control and scheduling services to customers of both the Space Network and selected Ground Networks elements.

### **STRATEGY FOR ACHIEVING GOALS**

This program develops and maintains both the management and technical interfaces for customers of the Space Network. The Network Control Center (NCC), located at the Goddard Space Flight Center in Maryland, is the primary interface for all customer missions. The primary function of the NCC is to provide scheduling for customer mission services. In addition the NCC generates and transmits configuration control messages to the network's ground terminals and TDRS satellites and provides fault isolation services for the network. The Customer Services program also provides comprehensive mission planning, user communications systems analysis, mission analysis, network loading analysis, and other customer services and tests to insure network readiness and technical compatibility for in-flight communications.

The AlliedSignal Technical Services Corporation and the Computer Sciences Corporation are the primary support service contractors responsible for systems engineering, software development and maintenance, operations, and analytical services. The two contractors established a voluntary partnership in 1996 for these services under the CNMOS performance based contract.

The Customer Services program also undertakes network adaptations to meet specific user needs and provides assistance to test and demonstrate emerging technologies and communications techniques. A low power, portable transmit/receive terminal, called Portcom, which operates with TDRS spacecraft has been demonstrated. Potential applications include data collection from remote sites where commercial capabilities do not exist, such as NOAA ocean research buoys and National Science Foundation (NSF) Antarctic activities. A series of tests are being conducted with Japanese and European satellites and data acquisition systems. These will explore interoperability of the NASA Space Network and the National Space Development Agency (Japan) (NASDA)/ESA communications systems for mutual provision of emergency operational spacecraft support.

### **MEASURES OF PERFORMANCE**

	<b><u>FY 1996</u></b> <b><u>Plan</u></b>	<b><u>FY 1996</u></b> <b><u>Actual</u></b>	<b><u>FY 1997</u></b> <b><u>Plan</u></b>	<b><u>FY 1997</u></b> <b><u>Revised</u></b>	<b><u>FY 1998</u></b> <b><u>Plan</u></b>
Number of NASA spacecraft events supported by the NCC	60,800	60,800	59,400	61,000	74,400

The FY 1996 and FY 1997 number of NASA Spacecraft events supported by the NCC will remain fairly stable until the FY 1998 additions for support of Landsat-7, EOS AM-1, and Space Station assembly activities.

### **ACCOMPLISHMENTS AND PLANS**

In FY 1996, implementation was continued on an improved, distributed architecture for the NCC. When completed, this modification will provide more efficient use of the network capabilities, improved ability to resolve scheduling conflicts among customer missions, and provide standard commercial protocols for both internal and customer interfaces. This architectural change will be undertaken over several years and accomplished segment by segment. The segment of the control center to be modified first is the service scheduling system.

Studies have been conducted on the establishment of a more robust remote terminal capable of full service provision to users in the TDRS zone of exclusion. The implementation of a full

service remote terminal on Guam began with the approved FY 1995 Operating Plan reprogramming action late in FY 1996. This terminal will eventually replace the current, less capable terminal located in Australia. This remote terminal has already proven invaluable in boosting the scientific return from the Compton Gamma Ray Observatory.

In FY 1997, NCC modifications to the scheduling system will continue including incorporation of standard commercial protocols into the control center interfaces. The development of a compact transponder, using new technology, suitable for use by new, small satellites will be continued. This dual award procurement will provide engineering models and a small number of flight units from both Cincinnati Electronics and Motorola. These small satellite transponders expand Space Network/TDRS use to a new class of missions. Antenna systems technology development for the smaller satellite class spacecraft will be initiated.

In FY 1998, the Space Network Customer Services program will provide for continued operations, maintenance, and modification of the NCC. The scheduling system modification will be completed and become operational. The communication and control segment modification effort will be initiated. This segment modification will complete the distributed architecture modifications and lower the life cycle cost of the Network Control Center.

The requested funding also provides for continuation of mission planning, customer requirements definition and documentation, mission and network operational analyses, customer communications systems analyses, test coordination and conduct, and other customer support services. An interoperability demonstration with the TRMM spacecraft and a Japanese data relay satellite precursor, Communications and Broadcasting Engineering Test Satellite (COMETS), will be conducted. Compatibility testing will be planned for TRMM, Landsat-7, EOS PM-1, International Space Station, WIRE, and upcoming NOAA missions in FY 1998. Simulations, engineering tests, and data flows will be conducted to verify communications designs and train mission control operators.